Probing Hidden Order and Magnetic Disorder in Correlated Electron Systems Using Spin Probes, DMR-0203524

A novel state of matter is believed to be present in the low-temperature regime of URu_2Si_2. The new state is achieved below 17 Kelvin (–256 °C) and it is not completely understood (hidden order).

In view of recent magnetic resonance, muon-spin rotation, and thermodynamic experiments under pressure and high magnetic fields, several new questions have been raised regarding this hidden-order.

Our NMR measurements at ambient pressure are helping elucidate the hidden order character. In particular, we are addressing issues related to one suggested scenario for hidden order: orbital antiferromagnetism (OAF).

Condensed Matter NMR at CSULA:

* PI (first from left above)
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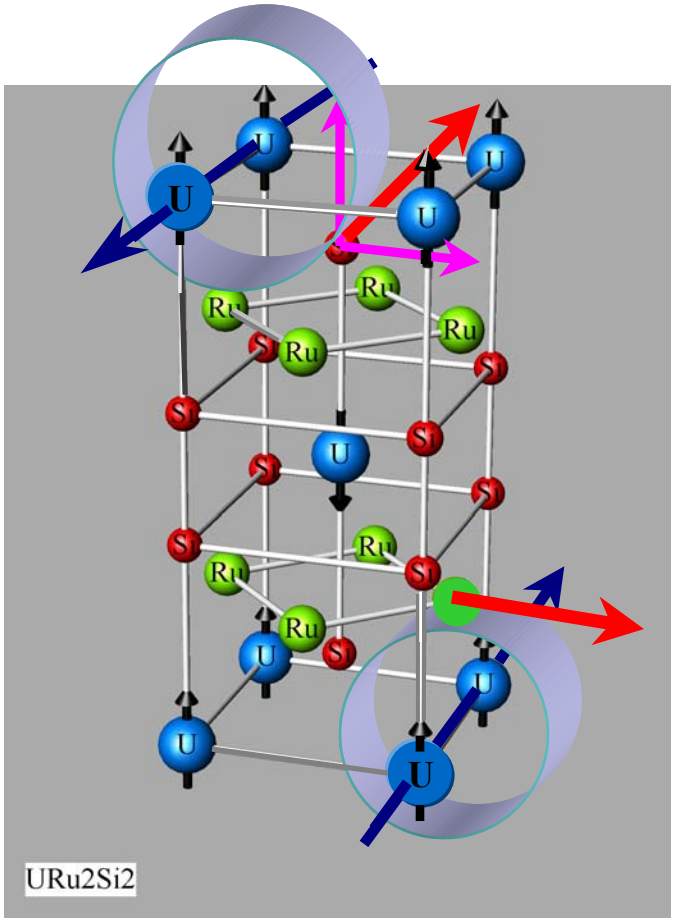
We have performed NMR in two of the isotopes available in the system: ^{29}Si and ^{99}Ru. Because the position of these isotopes is different within a single cell of the crystal (see illustration), they actually probe the local magnetic field at different environments allowing one to map the local configuration of the internal magnetism. We found previously that the internal field at the ^{29}Si sites is isotropic.

At right is a pictorial representation of the difference in local fields one expects to find in the low temperature state if OAF from U-U bond currents is present: isotropic field (equal vertical and horizontal components––pink arrows) at the ^{29}Si sites, but anisotropic (no vertical component) at the ^{99}Ru sites.



U-U Bond Current Direction

Resultant Magnetic Field

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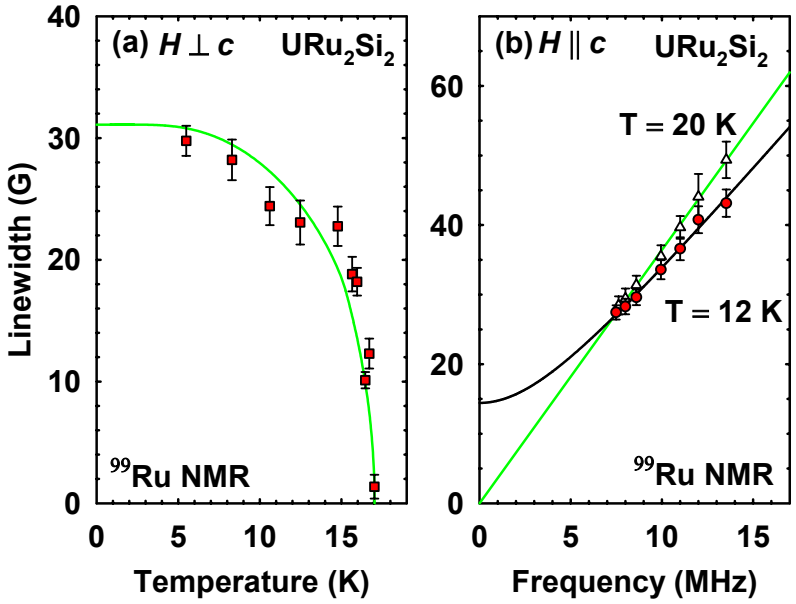
Graph (a) shows ^{99}Ru NMR linewidth vs. temperature when a magnetic field is applied in the horizontal direction. The increase below 17 Kelvin indicates the entrance to the hidden-order state (OAF?).

Typical internal fields along the horizontal direction can be inferred to be of order 30 gauss for the lowest temperatures.



Graph (b) shows ^{99}Ru NMR linewidth vs. applied radio frequency (proportional to the applied magnetic field strength) when the field is applied in the vertical direction. The change of the zero-frequency intercept from zero (for a temperature above 17 K) to non-zero (for a temperature below 17 Kelvin) indicates the entrance to the hidden-order state (OAF?).

The zero-frequency intercept gives a measure of the internal field, which is seen to be smaller than its counterpart in the previous case, i.e., anisotropic.